How the Risk Register Drives the Schedule Risk Analysis

David T. Hulett, Hulett & Associates, LLC (USA)
Waylon T. Whitehead, ConocoPhillips (USA)

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Agenda

- Risk Register identifies high-priority risks
- Explain “Risk Factors” approach
  - Risks have probability, impact
  - Risks are assigned to activities
- Compute Monte Carlo simulation results
- Estimate sensitivity and net effect of key risks
- Apply Risk Factors to simple space vehicle development schedule as an example
- Collecting risk data for the model
- How results are used to manage project risk

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Limitations with the Traditional 3-point Estimate of Activity Duration

- Typical schedule risk analysis starts with the activity that is impacted by risks
  - Estimates the 3-point estimate for optimistic, most likely and pessimistic duration
  - Creates a probability distribution for activity duration
  - Performs Monte Carlo simulation
- Which risks cause the most overall schedule risk? These questions are typically answered by:
  - Sensitivity to activity durations
  - Criticality of activity durations
  - **NOT sensitivity to the risks themselves**

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Some Problems with Traditional Approach

- Can tell which activities are crucial, but not directly which risks are driving
- Makes poor use of the Risk Register that is usually available
- Cannot decompose the overall schedule risk into its components BY RISK
  - Ability to assign the risk to its specific risk drivers helps with communication of risk causes and risk mitigation

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We Propose a Different Approach: Start with the Risks Themselves

- Drive the schedule risk by the risks already analyzed in the Risk Register
- For each risk, specify:
  - Probability it will occur
  - Impact on time if it does
  - Activities it will affect
- Starting with the risks themselves gives us benefits
  - Links qualitative analysis to the quantitative analysis
  - Estimates the impact of specific risks for prioritized mitigation purposes

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Simple Example of Risk Register Risks

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be more Difficult than Planned	100.00%	110.00%	130.00%	100.00%
2.	Technical Labor Productivity may Vary	90.00%	100.00%	115.00%	50.00%
3.	Construction Labor Productivity may Vary	90.00%	100.00%	115.00%	100.00%

- Use the Risk Factors module in Pertmaster 8
- Collect probability and impact data on risks
- Load the risks
- Assign risks to schedule activities

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Risk Factors Mechanics (1)

- The risk factor is assigned to one or several activities, affecting their durations by a multiplicative factor
  - E.g., the factor may be .90 for optimistic, 1.0 for most likely and 1.25 for pessimistic
  - These factors multiply the schedule durations of the activities to which they are assigned
- Risks can be assigned to one or more activities
- Activity durations can be influenced by one or more risks

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Risk Factors Mechanics (2)

- Risk Factors are assigned a probability of occurring on any iteration.
  - When the risk occurs, the factor used is chosen at random from the 3-point estimate and operates on all activities to which it is assigned
  - When not occurring on an iteration the risk factor takes the value 1.0, a neutral value
- When an activity is influenced by more than one risk, their factors are multiplied together, if they happen, on any iteration

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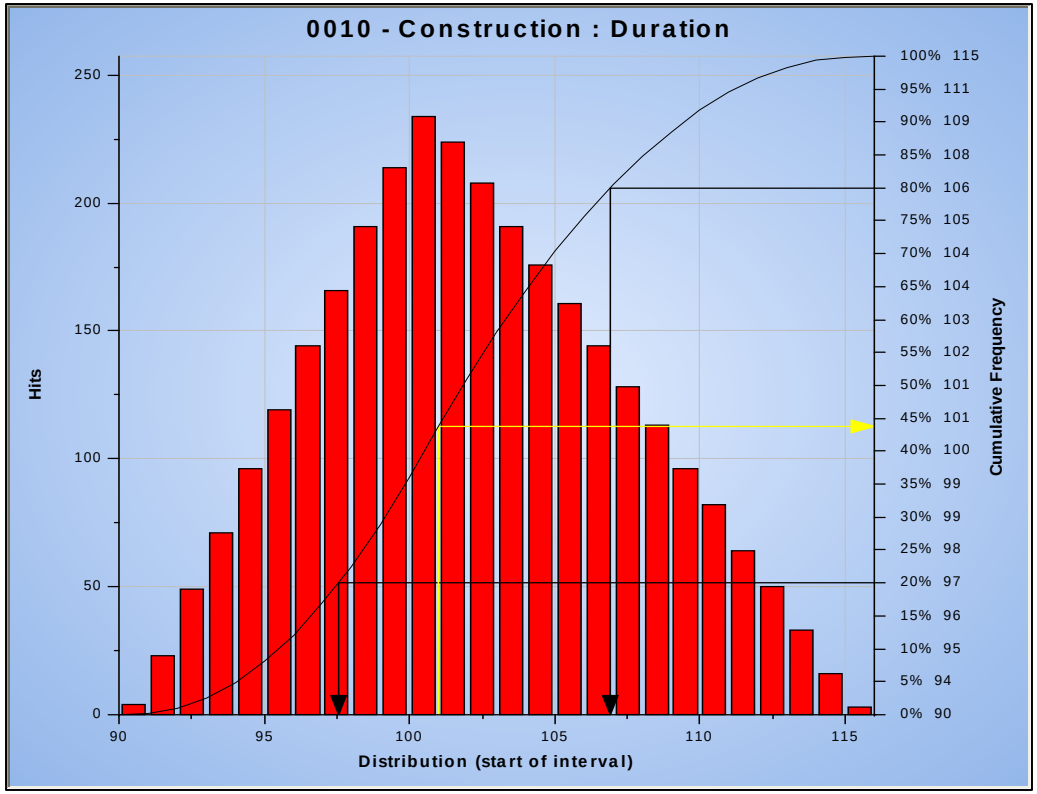
Risk Factor
Applied to a 100 day Task (1)

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Construction Labor Productivity May Vary	90%	100%	115%	100%



Here the Ranges are based on deviations + and – from the Plan. Probability is 100%

For the examples we use an activity with 100 days in the schedule

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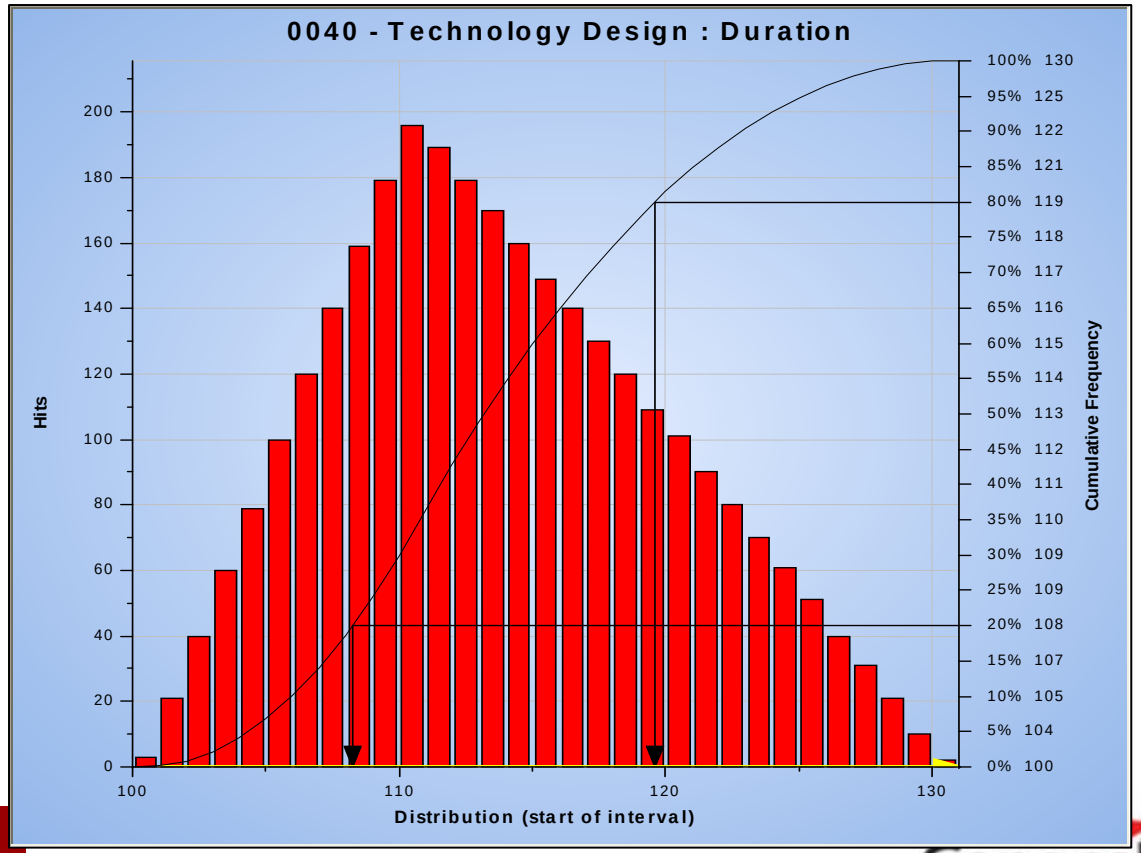
Risk Factor
Applied to a 100-day Task (2)

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be More Difficult than Planned	100.00%	110.00%	130.00%	100.00%

Here the Plan is the Optimistic Value. Probability is 100%



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Assigning a Probability Less than 100%

- The essence of “risk” is the uncertainty
  - Uncertainty of its occurrence, specified by a probability
  - Uncertainty of its impact, specified by a range of durations
- If the risk may or may not occur, we specify the probability that it will occur
  - The risk occurs and affects the activities it is assigned to on X% of the iterations, chosen at random
  - On (1 – X)% of the iterations, the plan value is used

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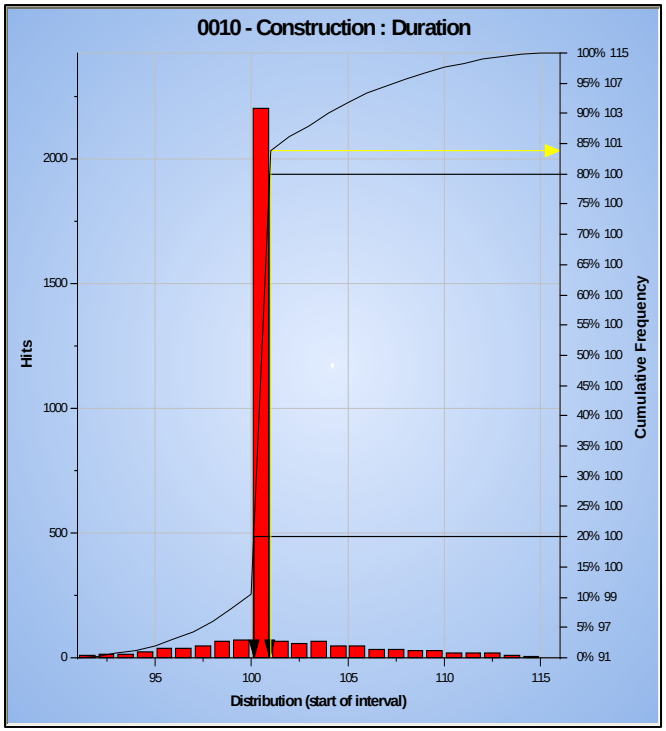
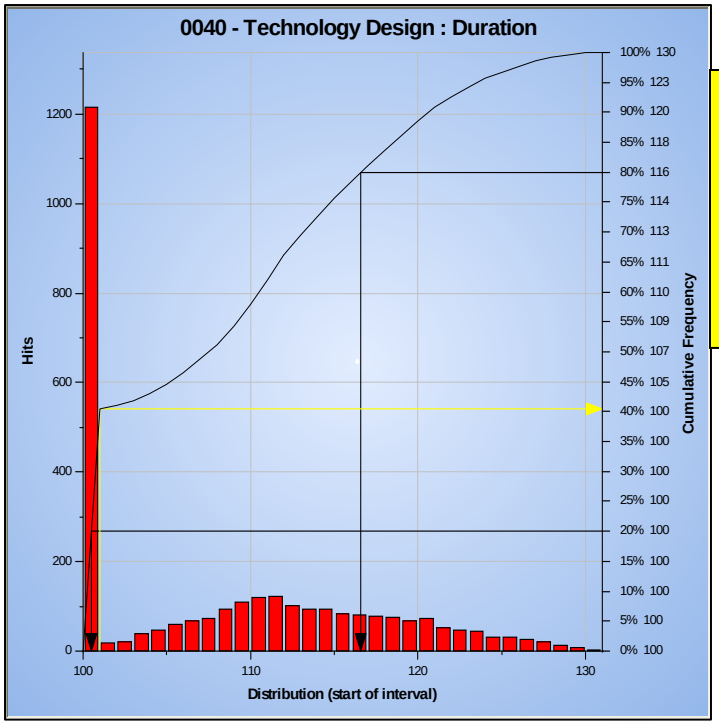
Assigning a Probability Less than 100%

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be more Difficult than Planned	100.00%	110.00%	130.00%	60.00%
2.	Construction Labor Productivity May Vary	90.00%	100.00%	115.00%	30.00%

Spike contains 70% of the probability





Spike contains 40% of the probability

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Assigning
More than One Risk to an Activity

- If more than one risk is acting on an activity, the resulting ranges are the multiplication of the percentages
  - Risk 1 has 90%, 100% and 115%
  - Risk 2 has 100%, 110% and 130%
  - The resulting risk has ranges of
    - Optimistic: 90% (.9 x 1.0)
    - Most Likely:110% (1.0 x 1.1)
    - Pessimistic:150% (1.15 x 1.3)

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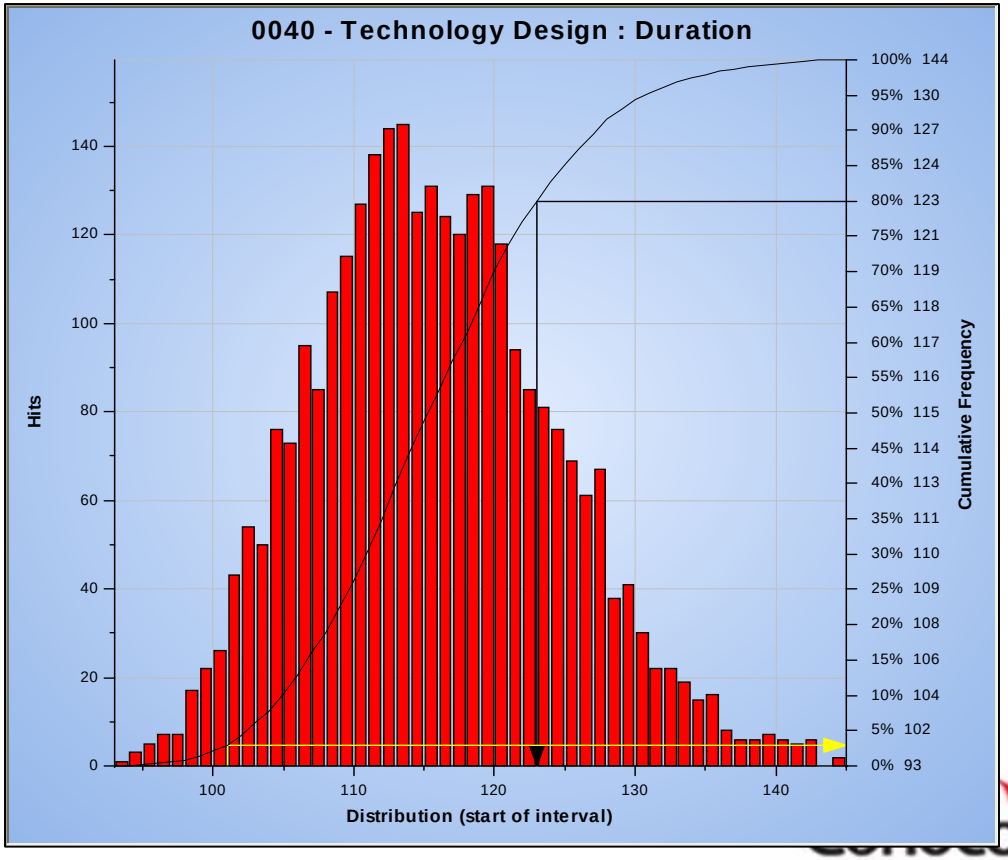
Two Risks affect One Activity using Factors

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be more Difficult than Planned	100%	110%	130%	100%
2.	Technical Labor Productivity May Vary	90%	100%	115%	100%



Range from 90 to 150 days, Peak about 113 days

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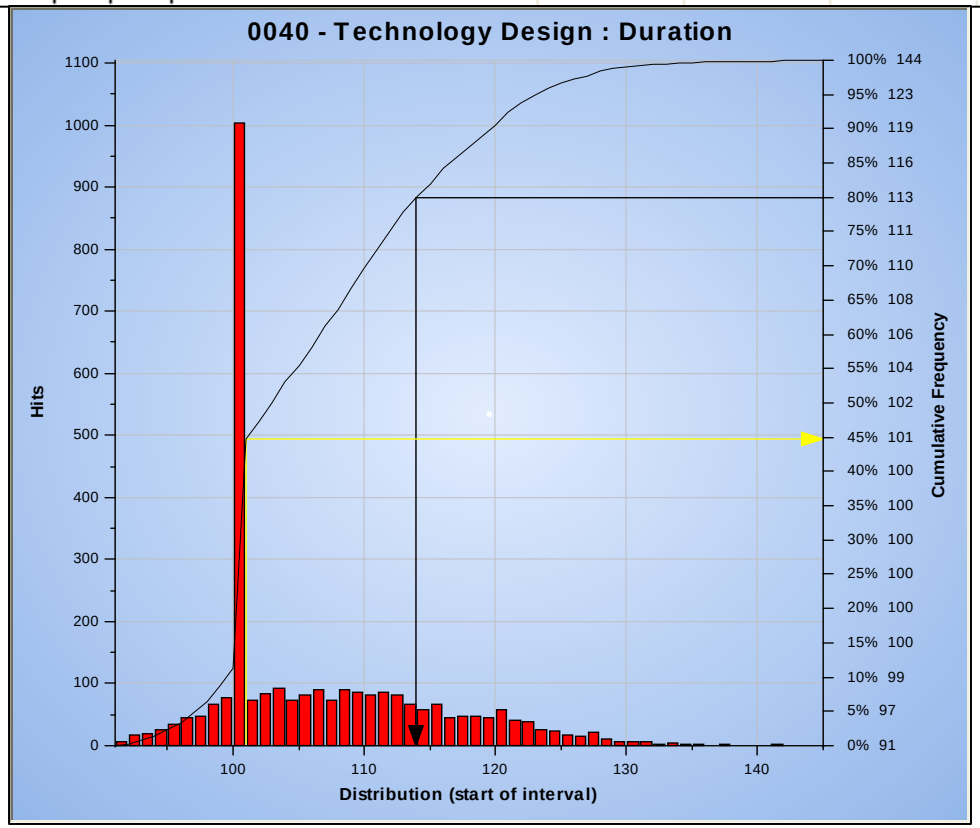
Two Risks with Less than 100% Probability Affecting one Activity

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be more Difficult than Planned	100.00%	110.00%	130.00%	40.00%
2.	Technical Labor Productivity May Vary	90.00%	100.00%	115.00%	50.00%



The spike at 100 days represents (1) the likelihood that neither risk occurs and (2) the chance that 100 days is picked when one or both occur

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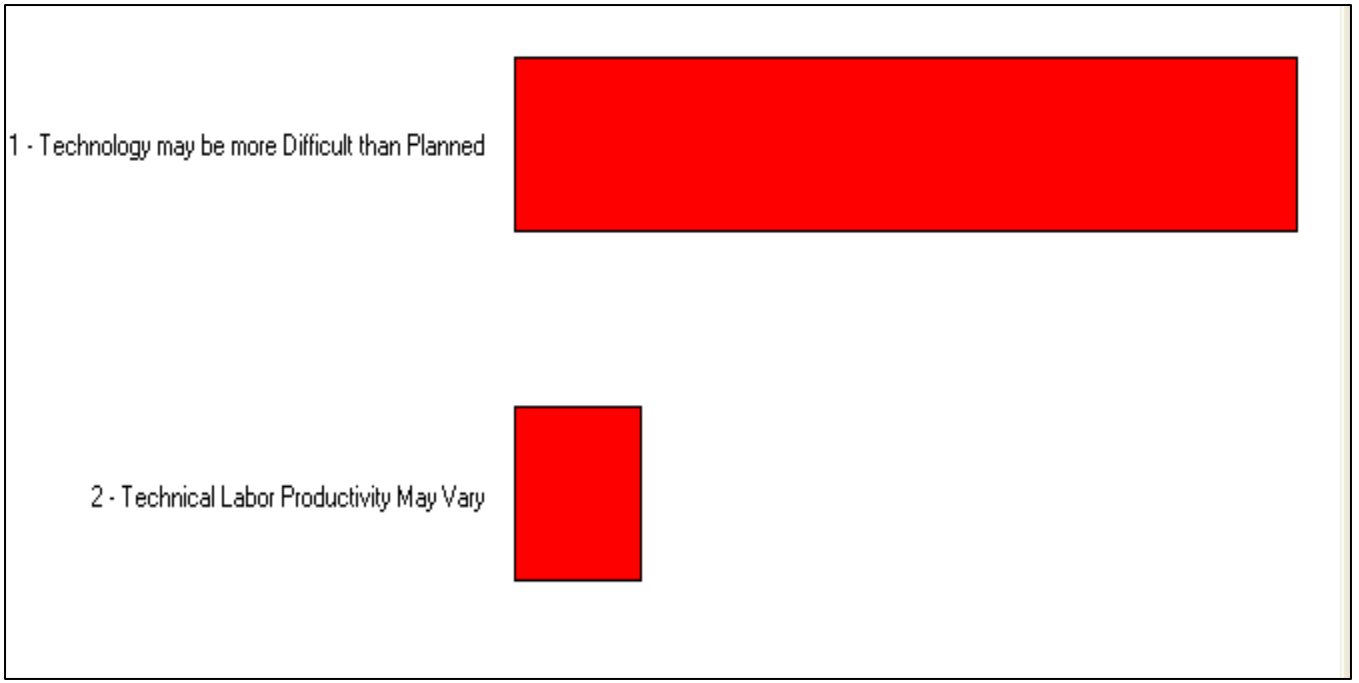
Sensitivity to the Risk Factors

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Technology may be more Difficult than Planned	100.00%	110.00%	130.00%	40.00%
2.	Technical Labor Productivity May Vary	90.00%	100.00%	115.00%	50.00%

Risk #1 has larger percentage extremes but Risk #2 has a higher probability.



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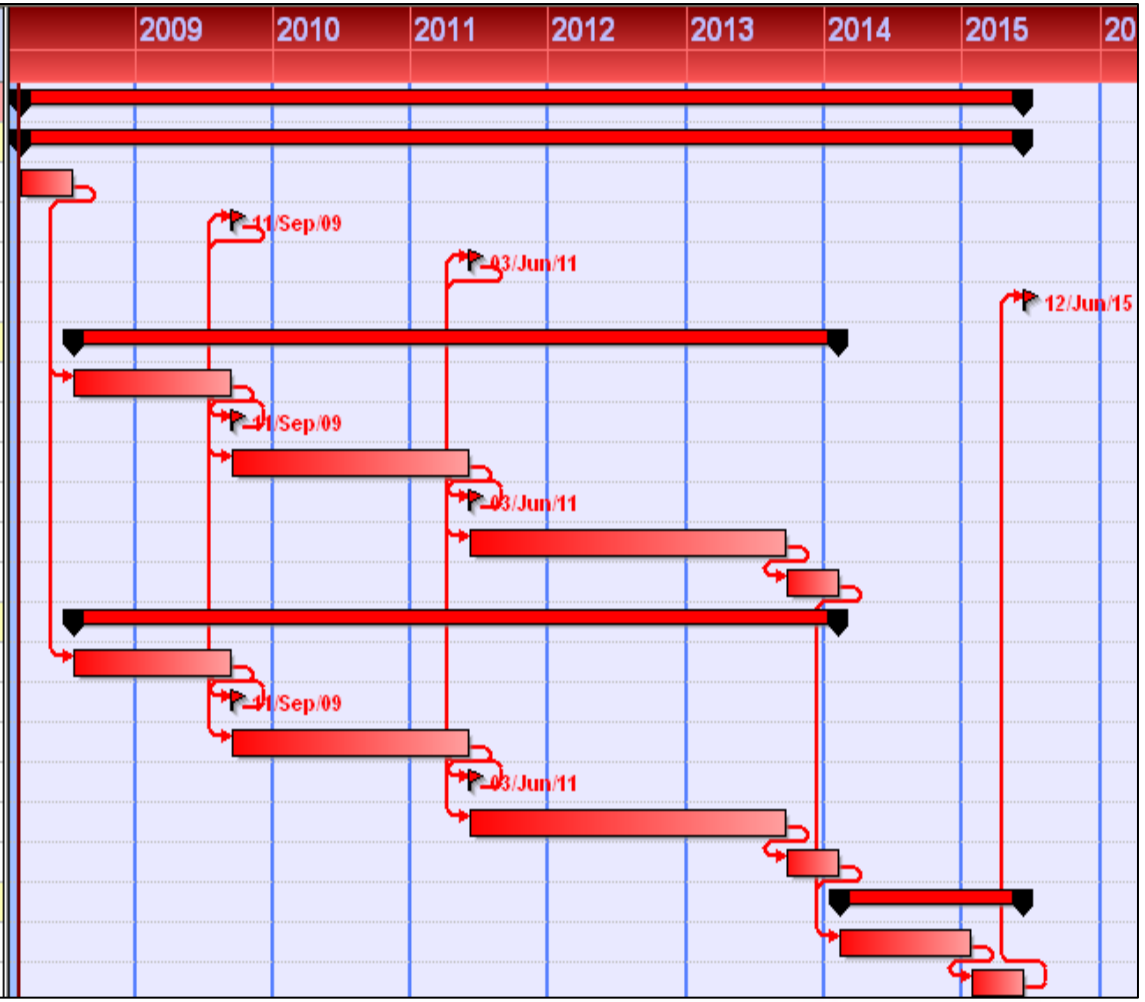
Simple 2-Stage Space Vehicle Schedule

ID	Description	Rem Duration	Start	Finish
SUMMA	**Project summary - used for se...**	**1900**	**03/Mar/08**	**12/Jun/15**
00001	**Spacecraft Project Milestones**	**1900**	**03/Mar/08**	**12/Jun/15**
0000	Requirements Definition Spacecraft	100	03/Mar/08	18/Jul/08
0000	**PDR Spacecraft**	**0**		**11/Sep/09**
0000	**CDR Spacecraft**	**0**		**03/Jun/11**
0000	**Ship to Launch Site**	**0**		**12/Jun/15**
00006	**First Stage**	**1450**	**21/Jul/08**	**07/Feb/14**
0000	FS Preliminary Design	300	21/Jul/08	11/Sep/09
0000	**FS PDR**	**0**		**11/Sep/09**
0000	FS Final Design	450	14/Sep/09	03/Jun/11
0001	**FS CDR**	**0**		**03/Jun/11**
00011	FS Fabrication	600	06/Jun/11	20/Sep/13
0001	Test FS Engine	100	23/Sep/13	07/Feb/14
00020	**Upper Stage**	**1450**	**21/Jul/08**	**07/Feb/14**
00021	US Preliminary Design	300	21/Jul/08	11/Sep/09
0002	**US PDR**	**0**		**11/Sep/09**
0002	US Final Design	450	14/Sep/09	03/Jun/11
0002	**US CDR**	**0**		**03/Jun/11**
0002	US Fabrication	600	06/Jun/11	20/Sep/13
0002	US Test	100	23/Sep/13	07/Feb/14
00027	**Integration**	**350**	**10/Feb/14**	**12/Jun/15**
0002	Integration	250	10/Feb/14	23/Jan/15
0002	Integration Testing	100	26/Jan/15	12/Jun/15



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Software used: Pertmaster v. 8.0

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Simple Space Vehicle Development Schedule

- 87 month schedule
  - 67 months for design, fabrication, and test of FS, US
  - 16 months of integration and test
- 10 activities linked
- Beginning 3 March 2008
- PDR on 11 SEPT 2009
- CDR on 3 June 2011
- Delivery to launch site 7 Feb 2014

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Two Types of Risk

- Background risk based on typical general risk, estimating error
  - Used Quick Risk of -5% and +10%
- Discrete risks derived from Risk Register
  - Summarized from detailed Risk Register
  - These have a probability of occurring and an impact on specific activities if they do
  - Parallel to their Risk Register information, which is used in data collection

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Schedule Including Background Risk

Background risk:
Optimistic -5% and
Pessimistic +10%

ID	Description	Rem Duration	Start	Finish	Minimum Duration	Most Likely	Maximum Duration
SUMMA	**Project summary - used for se...**	**1900**	**03/Mar/08**	**12/Jun/15**			
00001	**Spacecraft Project Milestones**	**1900**	**03/Mar/08**	**12/Jun/15**			
00002	Requirements Definition Spacecraft	100	03/Mar/08	18/Jul/08	95	100	110
00003	**PDR Spacecraft**	**0**		**11/Sep/09**			
00004	**CDR Spacecraft**	**0**		**03/Jun/11**			
00005	**Ship to Launch Site**	**0**		**12/Jun/15**			
00006	**First Stage**	**1450**	**21/Jul/08**	**07/Feb/14**			
00007	FS Preliminary Design	300	21/Jul/08	11/Sep/09	285	300	330
00008	**FS PDR**	**0**		**11/Sep/09**			
00009	FS Final Design	450	14/Sep/09	03/Jun/11	428	450	495
00010	**FS CDR**	**0**		**03/Jun/11**			
00011	FS Fabrication	600	06/Jun/11	20/Sep/13	570	600	660
00012	Test FS Engine	100	23/Sep/13	07/Feb/14	95	100	110
00020	**Upper Stage**	**1450**	**21/Jul/08**	**07/Feb/14**			
00021	US Preliminary Design	300	21/Jul/08	11/Sep/09	285	300	330
00023	**US PDR**	**0**		**11/Sep/09**			
00023	US Final Design	450	14/Sep/09	03/Jun/11	428	450	495
00024	**US CDR**	**0**		**03/Jun/11**			
00025	US Fabrication	600	06/Jun/11	20/Sep/13	570	600	660
00026	US Test	100	23/Sep/13	07/Feb/14	95	100	110
00027	**Integration**	**350**	**10/Feb/14**	**12/Jun/15**			
00028	Integration	250	10/Feb/14	23/Jan/15	238	250	275
00029	Integration Testing	100	26/Jan/15	12/Jun/15	95	100	110

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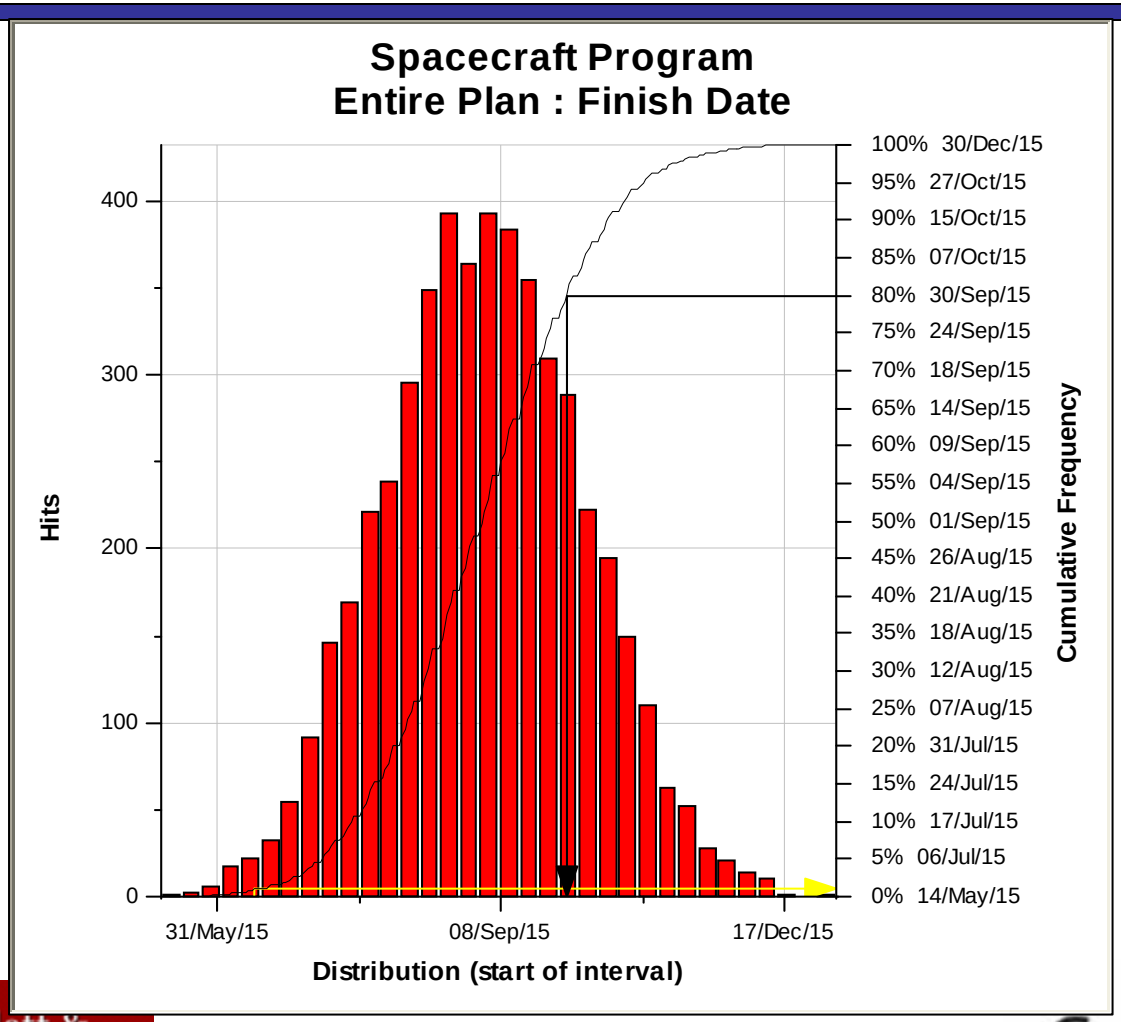
Results with Background Risk Only



Deterministic: 12JUN15 is <1%

P-80 is 30SEP15, about 3.5 months later than planned

Spread from P-5 to P-95 is 5JUL15 to 27OCT15 for 3.7 months

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Discovery of Risk Factors

- From exploratory interviews w/ all project stakeholders to arrive at their general ideas about what the risks are
- From the project risk register (each risk listed on the risk register should be “mapped” to one Risk Factor)
- From general knowledge about conditions (market, analogous data) that might affect the project

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Detailed Interviews for Information about Risk Factors

- Using the arrived at Risk Factors, conduct interviews to assess their likelihood and impact
- Be alert to the discussion of new risks during the interviews
- The use of pre-read information can assist with the amount of information that can be covered in a time limited interview

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Applying Risk Factors

- Where possible, cover what type of schedule activities the risk factor will apply to
- Be alert to the need for applying the same risk factor with more than one range for different types of activities
- Be alert to the need to divide schedule activities in order to discretely apply Risk Factors

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Risk Analysis on Space Vehicle Project Risk Factors are from Risk Register

	Description	Optimisitic	Most Likely	Pessimisitic	Likelihood
1.	Requirements have not been decided	95.00%	105.00%	120.00%	30.00%
2.	Several alternative designs considered	95.00%	100.00%	115.00%	60.00%
3.	New designs not yet proven	96.00%	103.00%	112.00%	40.00%
4.	Fabricaton requires new materials	96.00%	105.00%	115.00%	50.00%
5.	Lost know-how since last full spacecraft	95.00%	100.00%	105.00%	30.00%
6.	Funding from Congress is problematic	90.00%	105.00%	115.00%	40.00%
7.	Schedule for testing is aggressive	100.00%	120.00%	130.00%	100.00%

- Seven risk factors have been identified and quantified.
- Each Risk has probability assigned
- Some have optimistic ranges possible, others are pure threats

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Risks Assigned to Activities (1)

Risk	Requirements Definition	FS Preliminary Design	FS Final Design	FS Fabrication	Test FS Engine
Requirements Not Complete	X				
Alternative Designs Possible		X			
Designs Not Proven			X		
New Materials in Fabrication				X	
Lost Know-How				X	
Funding Problematic		X	X	X	X
Testing Schedule Aggressive					X

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Risks Assigned to Activities (2)

Risk	US Preliminary Design	US Final Design	US Fabrication	US Test	Integration	Integration Testing
Requirements Not Complete						
Alternative Designs Possible	X					
Designs Not Proven		X				
New Materials in Fabrication			X			
Lost Know-How			X		X	
Funding Problematic	X	X	X	X	X	X
Testing Schedule Aggressive				X		X

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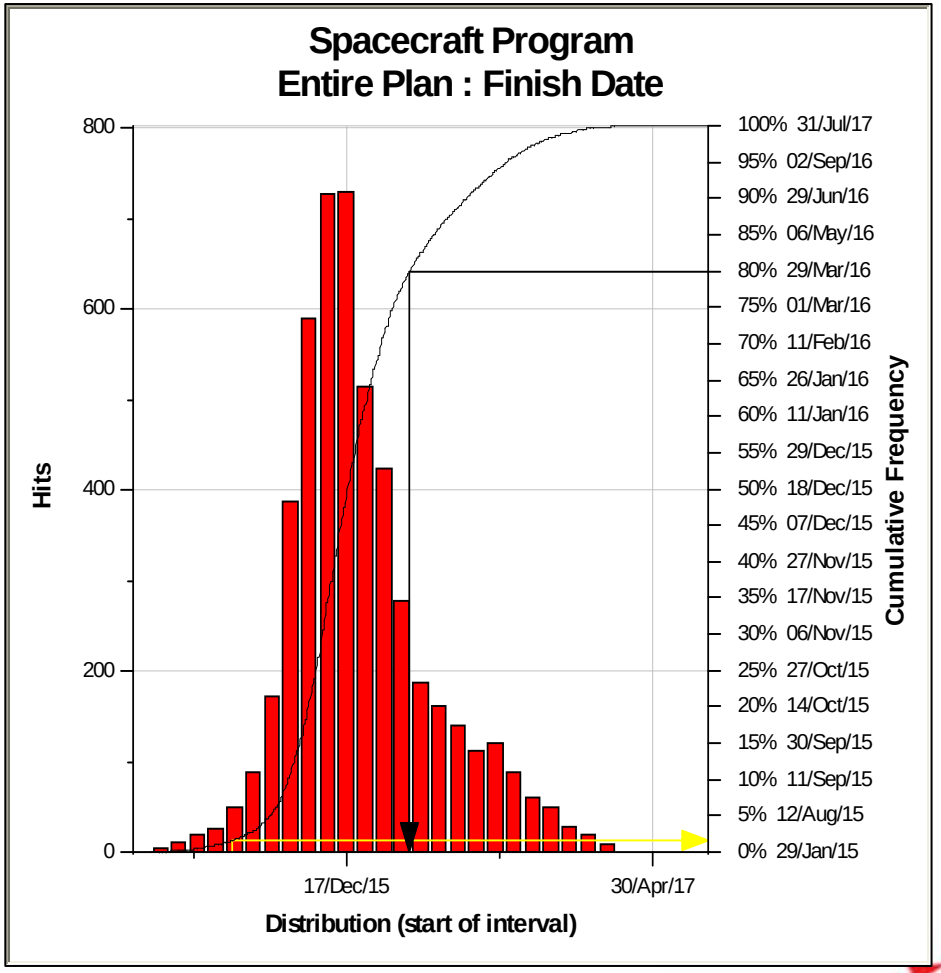
Results Adding Risk Factors to the Background Risk

Baseline 12JUN 15 is only 3% likely

The 80th percentile (P-80) is 29MAR16, 9.5 months later

Spread P-5 to P-95 is 12AUG15 to 2SEP16, for 12.5 months



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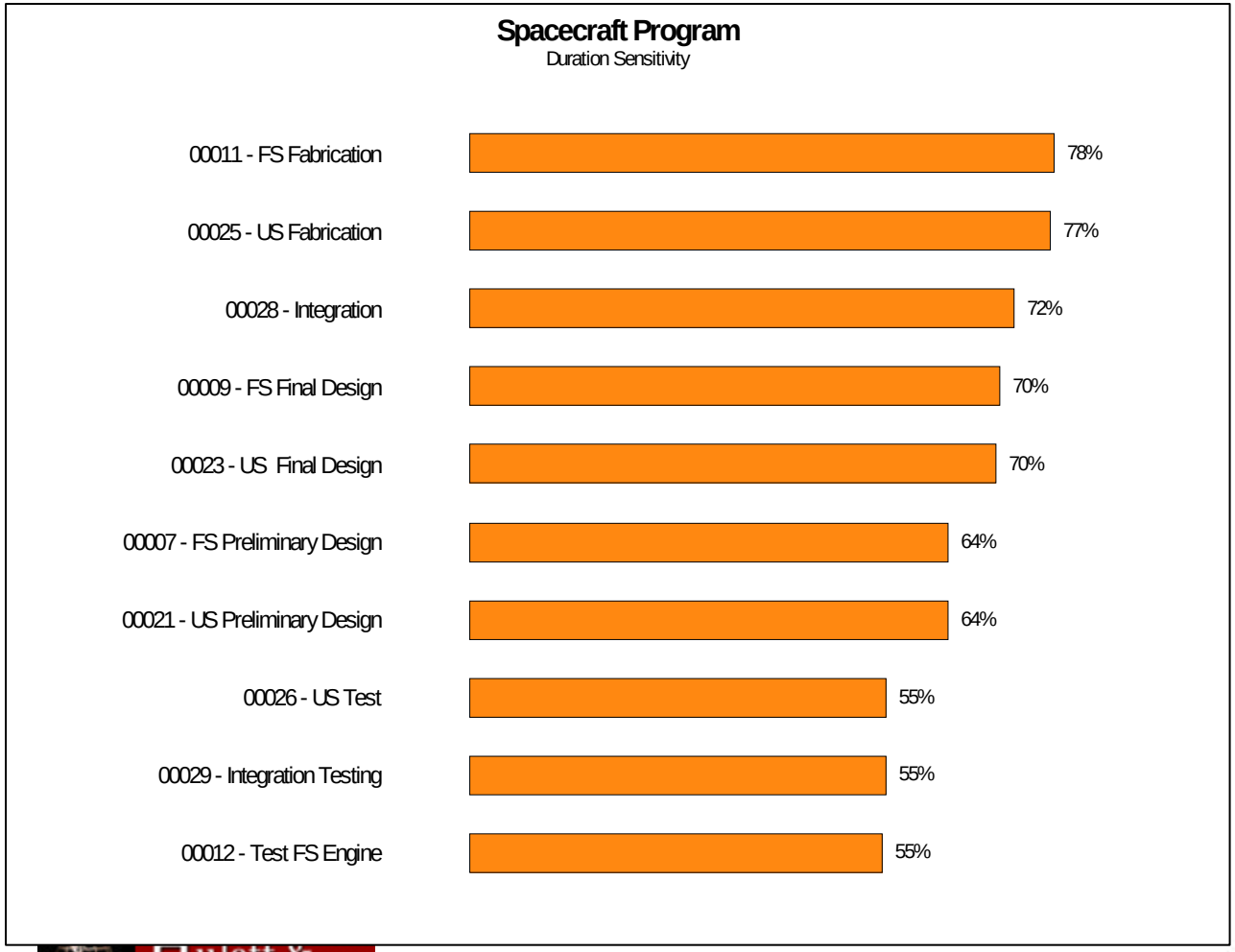
Activity Tornado Chart from All-In Simulation



Risky Activities: Fabrication, Integration, Final Design, Preliminary Design, Testing

All except testing have about the same influence

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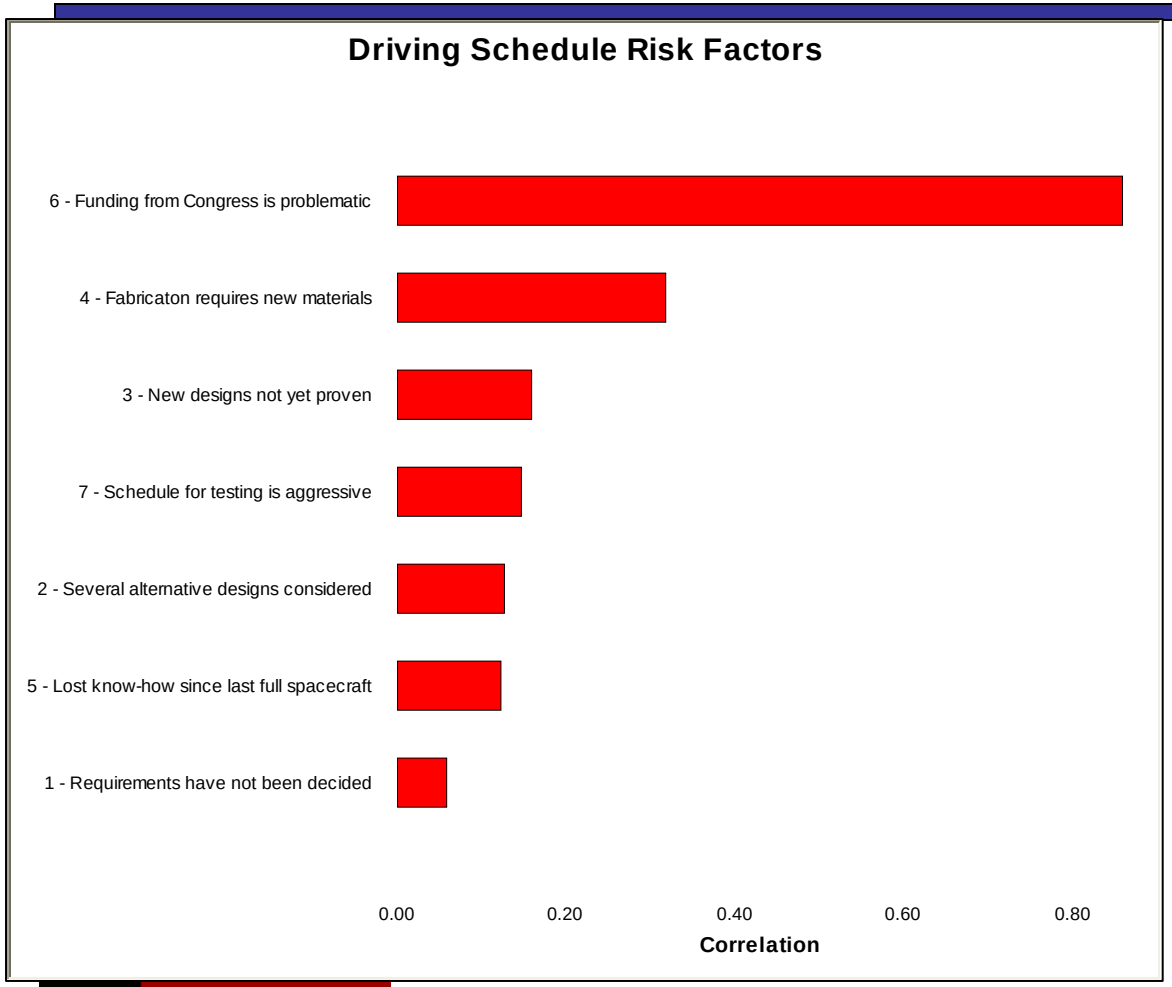
Risk Factor Tornado from All-In Simulation



The main RISK, however, is funding from Congress, which affected all activities. This is the main risk to mitigate, if possible

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Contribution of Each Risk to the Contingency (1)

Explain the Contingency to the P-80			
	P-80 Date	Take Risks Out:	
All Risks In	6-Jun-16	Days Saved	% of Contingency
Specific Risks Taken Out in Order			
No Funding Risk	19-Jan-16	139	39%
No Tight Testing Schedule Risk	1-Dec-15	49	14%
No New Design Risk	15-Oct-15	47	13%
No Alternative Design Risk	5-Oct-15	10	3%
No Lost Know How Risk	2-Oct-15	3	1%
No Requirements Risk	30-Sep-15	2	1%
Background Schedule Estimating Risks			
No Background Risk	12-Jun-15	110	31%
Total Contingency		360	100%

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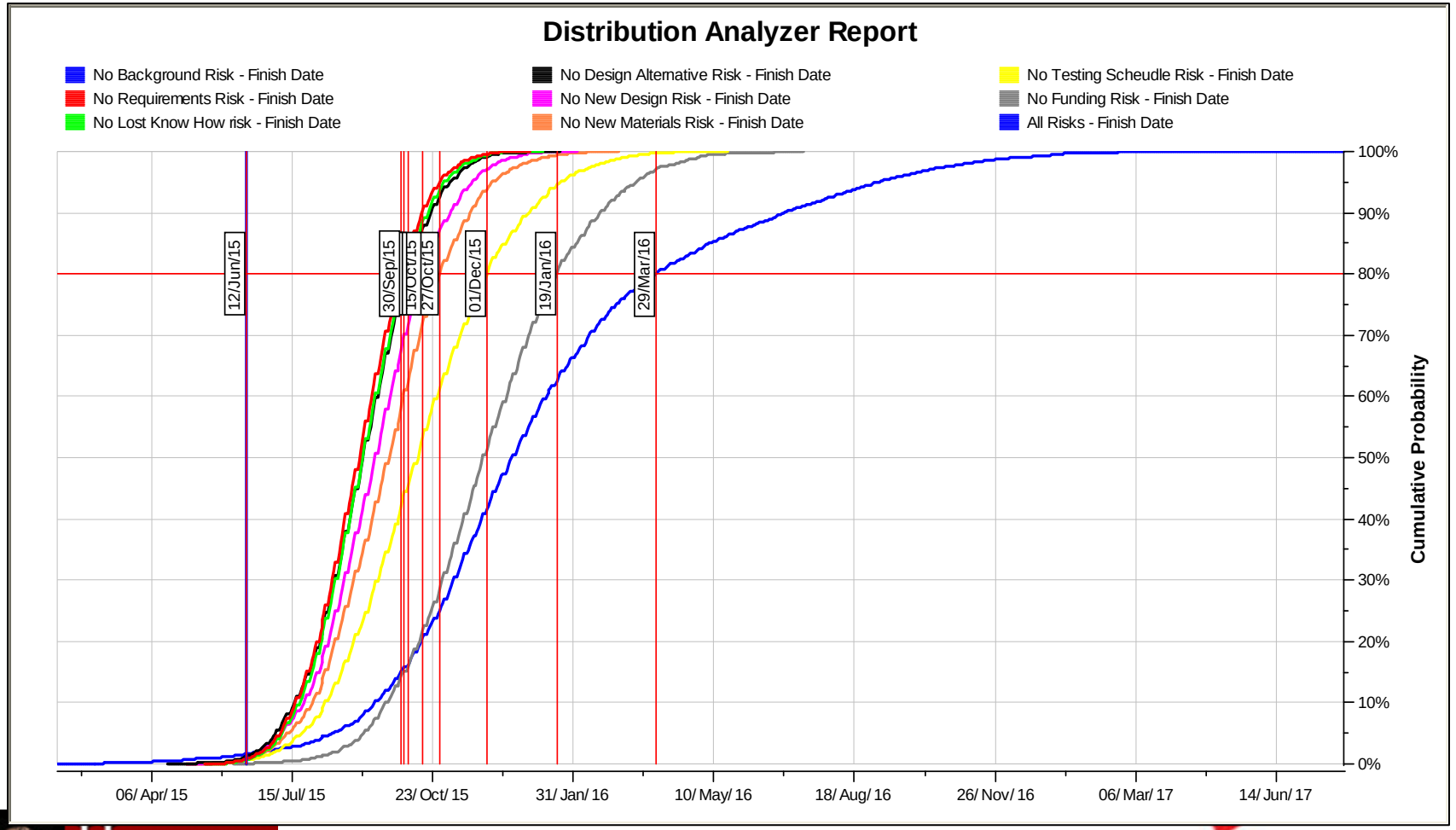
Contribution of Each Risk to the Contingency (2)



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Summary (1)

- The focus is on the risks, not their impact
- Risks “explain” the need for a contingency
- Management appreciates this focus on risks
- Risk interviews are conducted at 20,000 foot level, where people typically think of risk
- Interviews go faster, stick to the substance

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Summary (2)

- Risk Register exists, use it for quantitative analysis
- Specific risks can be quantified and assigned to schedule activities
  - Quantification is probability and impact
  - A risk can affect several activities
  - An activity can be affected by several risks
- Risk Factors can be combined with other more traditional approaches such as 3-point estimates for background risk or probabilistic branching

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Using the Risk Register in Schedule Risk Analysis with Monte Carlo Simulation

David T. Hulett, Hulett & Associates, LLC (USA)
Waylon T. Whitehead, ConocoPhillips (USA)

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